Putting the "systematic" into searching — tips for search strategies in systematic reviews

Douglas JC Grindlay, Alexia Karantana

Centre for Evidence Based Hand Surgery (CEBHS), School of Medicine, University of Nottingham, Nottingham, NG7 2UH, UK.

Corresponding author contact details:

douglas.grindlay@nottingham.ac.uk

Tel: +44 (0) 115 8231113

Dr Douglas Grindlay, Centre for Evidence Based Hand Surgery, University of Nottingham, Queens Medical Centre, Nottingham, NG7 2UH, UK.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article. The Centre for Evidence Based Hand Surgery (CEBHS) is a collaboration between, and is co-funded by, the British Society for Surgery of the Hand, the University of Nottingham and Nottingham University Hospitals NHS Trust.

Putting the "systematic" into searching — tips and resources for search strategies in systematic reviews

The quality of the methodology of published systematic reviews in hand surgery is highly variable. This is especially the case with the proliferation of non-Cochrane Reviews in recent years. There are many potential deficiencies in systematic review methods which can lead to a risk of bias or erroneous conclusions (Garcia-Doval et al., 2017).

A fundamental aspect is the quality of the literature search strategies employed. Some published systematic reviews in hand surgery have search strategies that are simplistic, omit relevant terms, or contain basic syntax errors, while some do not search a comprehensive range of databases. In some cases the search strategy is not even documented adequately or at all, despite the requirements of the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) reporting guideline (Moher et al., 2009). This means the search strategy cannot be checked and reproduced (a key indicator of quality). A poor search can lead to the omission of relevant studies, with a potentially significant impact on any subsequent analysis and the conclusions reached.

In this article we aim to provide helpful tips for systematic review authors to avoid common errors and optimise their search strategies. The article should also help readers to critically appraise and interpret existing reviews. It is not intended as a comprehensive guide to systematic searching. Detailed advice on searching for studies is available online in the *Cochrane Handbook for Systematic Reviews of Interventions* (Lefebvre et al., 2011).

It takes time and expert training to learn how to compile a comprehensive and sensitive search strategy, and there are many pitfalls for the unwary. We suggest that it is always best to attend a systematic review training course to learn from experts before starting.

Choice of databases to search

Ideally, any systematic review should search more than one database to maximise the likelihood of finding all relevant studies. We would suggest a combination of MEDLINE (https://www.nlm.nih.gov/bsd/pmresources.html), Embase (https://www.elsevier.com/en-gb/solutions/embase-biomedical-research), and Cochrane CENTRAL (http://www.cochranelibrary.com/about/central-landing-page.html) as a minimum for a systematic review on interventions. This combination was also suggested by Le Cleach et al. (2016).

There is sometimes confusion by systematic review authors about the difference between bibliographic databases and search interfaces. Several databases are available through more than one search interface, with each interface having its own search commands and syntax. An interface that is widely used in systematic reviews is Ovid (http://www.ovid.com). Ovid is particularly suited to building up systematic searches term by term, and can be used to search multiple databases. Examples of alternative interfaces include Ovid MEDLINE or PubMed, and Ovid Embase or Embase.com. If the free interface PubMed (https://www.ncbi.nlm.nih.gov/pubmed) is used to search MEDLINE, this should be stated, as PubMed includes some content in addition to MEDLINE. In particular PubMed has a collection of open-access journals in PubMed Central (PMC), not all of which are indexed for MEDLINE.

Often MEDLINE or PubMed are the only databases searched in hand surgery systematic reviews. However, they do not include all refereed medical journals, so there is potential to miss relevant studies. For this reason we suggest combining MEDLINE or PubMed with Embase, as there are over 2,900 indexed journals unique to Embase (https://www.elsevier.com/en-gb/solutions/embase-biomedical-research), including journals from Eastern Europe and Asia. Embase also includes conference abstracts, whereas MEDLINE and PubMed do not, so authors may want to consider this if a review is to include more than full text articles.

CENTRAL is a comprehensive database of randomised controlled trials compiled from individual Cochrane Group trial registers, hand searching and regular database searches. It includes unpublished trials and trial reports that are not included in MEDLINE, PubMed nor Embase, hence the recommendation it is included in searches on interventions.

Finally, depending on the topic of the systematic review, it may be appropriate to include other, more specialised databases in addition to the three suggested above. Suggestions for relevant databases in different topic areas are shown in Table 1.

Identifying search concepts

A systematic search strategy is constructed by defining the search concepts on the basis of a carefully constructed research question. It helps the reader if the report of a systematic review specifically states the research question and the search concepts involved—these are not always clear in published systematic reviews.

It is common to use a "PICO" question for reviews of interventions and a "PEO" question for a review of risk factors, such as comorbidities etc. In a PICO question, the search concept P stands for patient or population, I for intervention, C for comparator and O for

outcome. An example PICO question would be the efficacy and safety of endoscopic release versus conventional surgery for patients with carpal tunnel syndrome. In a PEO question, P stands for patient or population, E for exposure and O for outcome. An example PEO question would be the association between Dupuytren's disease in adults and diabetes mellitus.

However, PICO and PEO are only guides in identifying the search concepts—authors should think carefully about what defines the studies of interest in constructing their search strategy. Generally it is desirable to keep the number of search concepts to be combined to a minimum to avoid excluding a relevant study, although this has to be balanced against the risk of getting too many search results to handle. The outcome O is an essential component of PEO questions and needs to be included in the search strategy. However, the outcome O is often omitted in the search strategy for PICO questions, as it can be difficult to define a comprehensive list of outcome terms, and the outcomes may not actually be mentioned in the title or abstract.

It helps to look at the strategies used for similar systematic reviews, especially if there is indication that an information specialist was involved in compiling the search. In the Cochrane Library (http://www.cochranelibrary.com) expert search strategies are available in both published Cochrane Reviews and Cochrane Review Protocols.

Constructing search strategies

The next step is to compile a comprehensive list of alternative terms or synonyms for each search concept. These alternative terms are combined in the search strategy with the Boolean operator OR. Boolean operators (or terms) are used to define the logic of relationships between sets. The search concepts are then combined using the Boolean operator AND. This identifies those records in the database that include all the search concepts in the search strategy.

The basic type of search terms most people are familiar with, e.g. when searching Google, is a "free text" search term. A free text term searches for a word (or words) in the different fields of the database records, *regardless of the word's meaning*. Hence, non-relevant articles will inevitably be retrieved for free text terms with multiple meanings. Examples of such terms include radius (the bone or radius of a circle), nails (of the fingers or metal nails), palm (hand or tree) and digital (finger or technology). Free text terms also retrieve articles regardless of their topic. Thus, a study whose abstract stated it included adults but not children would be found in a search for paediatric studies using the free text term "children".

For maximum sensitivity, a search strategy should also include "subject headings", if these are used by the bibliographic database. Subject headings are fixed terms for a given topic. Subject headings are derived from a thesaurus and are usually arranged in a hierarchy or tree structure. They are added to database records by the database producer when they are "indexed", on the basis of a subject analysis. In other words, they indicate what the article is *about*. Subject headings get round the problem of alternative terms and spellings (e.g. US and UK English) for the same topic. They may retrieve a relevant article when the fields in the database record do not include any of the expected free text terms. The best known subject headings are MeSH terms (Medical Subject Headings), as used in PubMed, MEDLINE and the Cochrane Library. Embase has its own, separate set of subject headings called Emtree terms.

The appropriate subject headings for a search concept can be identified in a variety of ways. Some search interfaces, such as Ovid and the Cochrane Library, have built-in tools ways to allow users to map entered terms to possible subject headings and then add them to their search. PubMed has automatic mapping to subject headings, which appear in the "Search details" box on the lower right of the PubMed results screen. However, this automated mapping depends on the correct interpretation of the meaning of the entered term and can be unpredictable, so should not be relied on in a systematic search. It is best to identify the relevant MeSH terms using the online MeSH browser (https://meshb.nlm.nih.gov/search), and then add them to a PubMed search strategy with the appropriate search command, for example "metacarpal bones"[MeSH Terms].

To avoid missing any relevant studies, it is important to take time to think about what terms might be used in the titles and abstracts of relevant studies, and to include all the possible free text terms for each search concept. Textbooks, web resources, relevant journal articles and published systematic review search strategies are all potential sources to identify relevant terms.

A good start is to consider the following:

1. Singular and plural terms (e.g. finger, fingers; phalanx, phalanges, phalanxes; junctura tendinum, juncturae tendinum)
2. Synonyms and abbreviations (e.g. scaphotrapeziotrapezoidal, triscaphe, triscaphoid, STT; triangular fibrocartilage, triangular cartilage, triangular fibrocartilaginous, TFCC; thromboangiitis obliterans, Buerger's disease)
3. Alternative spellings, especially UK and US English (e.g. anaesthesia, anesthesia; ischaemic, ischemic; haematoma, hematoma)
4. English and Latin terms (e.g. posterior tibial tendon, tibialis posterior tendon)

5. Permutations of terms (e.g. pronator {teres} syndrome; supinator {tunnel/entrapment} syndrome)
6. Hyphenated and non-hyphenated terms (e.g. radioulnar, radio-ulnar; peripisiform, peri-pisiform)
7. Separated and conjoined terms (e.g. opponens plasty, opponensplasty; clubhand, club hand; swan-neck, swan neck, swanneck)
8. Possessives (e.g. Bier's, Biers, Bier; Dupuytren's, Dupuytrens, Dupuytren)

For strings or phrases, i.e. two or more words together, keep them as short as possible and look for words in common when various permutations occur. Often a single common word will do. For example, the single term "supinator" may suffice for "supinator tunnel syndrome" and "supinator entrapment syndrome". When searching PubMed, strings should be put in inverted commas (e.g. "ganglion cyst", "radial styloidectomy"). Otherwise PubMed will automatically combine the two terms using AND, rather than searching for the two words occurring together in the specified order, giving additional, extraneous results.

As a final point, search strategies can easily be compiled as a single line strategy, with parentheses around the terms for each of the search concepts to ensure the correct logic of the Boolean operators. This approach is particularly suited to PubMed. Alternatively, in interfaces such as OVID, it is possible to build up search strategies line by line and subsequently combine lines with the appropriate Boolean operators.

Methodology filters for different study designs

Methodology filters to search for specific study designs are available for various databases and can be incorporated as part of a search strategy. Examples include filters for randomised controlled trials, observational studies and diagnostic studies. It is perhaps best to avoid using such filters as part of a formal systematic search strategy, as they inevitably bring a risk of missing relevant studies. However, filters may be essential if there would otherwise be too many search results to handle. If filters are used, ideally they should be highly sensitive and validated. A useful list of filters which can be referenced has been compiled by the InterTASC Information Specialists' Sub-Group:

https://sites.google.com/a/york.ac.uk/issg-search-filters-resource/home

Reporting search strategies

For purposes of transparency and repeatability, there should be enough information in the report of a systematic review to allow someone else to replicate the search and identify the same studies. The PRISMA Statement (Moher et al., 2009) indicates that a full electronic search strategy for at least one database should be given. This tends to be PubMed or Ovid MEDLINE, as they are best known. Usually the search strategy is provided in an appendix.

According to PRISMA, the date last searched should be recorded. As indicated earlier, it is also important to specify the search interface/supplier as well as the database name, as this affects the search commands that have to be used and the currency of the database on a given date.

Finally—involve an information specialist…

Key tips from this article for search strategies in systematic reviews are listed in Table 2.

There is no doubt that, with training and experience, clinical researchers can understand and avoid the common pitfalls and learn to be proficient searchers. However, in this age of specialism and rising standards, the ideal approach is to involve an expert—an information specialist or medical librarian with good experience of database searching for systematic reviews. Their expertise can be combined with your exact knowledge of the clinical research question and technical terms, for optimal results.

One of the key advantages of Cochrane Reviews is that Cochrane Group information specialists compile and/or check the search strategy, and are also involved in the peer review process. It has been demonstrated that involvement of librarians and information specialists improves the quality of the search strategies in systematic reviews (Rethlefsen et al. 2015). So the best advice is to seek out help from an expert searcher. You will learn a lot and produce a more reliable and useful systematic review as a result, and may also be one step closer to getting it published!

Extended resources

The Centre for Evidence Based Hand Surgery (CEBHS) has launched an open-access source of citations for systematic reviews relevant to hand surgery and therapy. This database offers a "one-stop" easy way to find systematic reviews. There are two free resources.

(1) **HandSRev**, a database and mapping of systematic reviews by topic that is updated monthly: https://www.nottingham.ac.uk/research/groups/cebhs/handsrev/index.aspx. (2) **Hand Surgery Evidence Updates**, free monthly e-mails that list and summarise new guidelines and systematic reviews as they are published: https://www.nottingham.ac.uk/research/groups/cebhs/evidence-updates/index.aspx.

CEBHS is a collaboration between, and is co-funded by, the British Society for Surgery of the Hand, the University of Nottingham and Nottingham University Hospitals NHS Trust.

References

Garcia-Doval I, van Zuuren EJ, Bath-Hextall F, Ingram JR. Systematic reviews: let's keep them trustworthy. Br J Dermatol. 2017, 177: 888-9.

Le Cleach L, Doney E, Katz KA, Williams HC, Trinquart L. Research techniques made simple: Workflow for searching databases to reduce evidence selection bias in systematic reviews. J Invest Dermatol. 2016, 136: e125-e129.

Lefebvre C, Manheimer E, Glanville J. Chapter 6: Searching for studies. In: Higgins JPT, Green S (Eds.) *Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0*. London: The Cochrane Collaboration, 2011.
http://handbook-5-1.cochrane.org/ (accessed 13/3/2018)

Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA Statement. BMJ. 2009, 339: b2535.

Rethlefsen ML, Farrell AM, Osterhaus Trzasko LC, Brigham TJ. Librarian co-authors correlated with higher quality reported search strategies in general internal medicine systematic reviews. J Clin Epidemiol. 2015, 68: 617-26.

Douglas JC Grindlay* and Alexia Karantana

Centre for Evidence Based Hand Surgery (CEBHS), School of Medicine, University of Nottingham, Nottingham, NG7 2UH, UK.

*Corresponding Author: douglas.grindlay@nottingham.ac.uk

Table 1. Suggested bibliographic databases for specialised topics relevant to hand surgery. Some of these databases are available through more than one search interface.

263

Topic	Database
Psychological or quality of life aspects	PsycINFO http://www.apa.org/pubs/databases/psycinfo/index.aspx
Physiotherapy	PEDro https://www.pedro.org.au
Sport	SPORTDiscus https://www.ebsco.com/products/research-databases/sportdiscus Physical Education Index http://www.proquest.com/products-services/pei-set-c.html
Nursing	CINAHL https://health.ebsco.com/products/the-cinahl-database
Allied and complementary medicine	AMED https://www.ebsco.com/products/research-databases/amed-the-allied-and-complementary-medicine-database
Basic science, technology or engineering	Web of Science http://wokinfo.com Scopus https://www.scopus.com/

264

265

266 Table 2. Tips for search strategies in systematic reviews

267

Searching:
(1) Use a combination of the databases MEDLINE, Embase and Cochrane CENTRAL as a recommended minimum for a systematic review on interventions.
(2) Consider adding in other, more specialised databases, or a general scientific database (Web of Science or Scopus), according to the topic of the review.
(3) Clearly identify the research question and the search concepts involved using the PICO or PEO format.
(4) Identify all possible free text terms for each search concept, using textbooks, web resources, journal articles and published search strategies as potential sources.
(5) Include the appropriate subject headings as well as free text terms.
(6) Keep strings or combinations of words as short as possible, and choose words in common when various permutations occur.
(7) In compiling alternative free text terms consider: Singular and plural terms; synonyms and abbreviations; alternative spellings (especially UK and US English); English and Latin terms; permutations of terms; hyphenated and non-hyphenated terms; separated and conjoined terms; possessives.
Reporting:
(1) Provide enough information in the report of a systematic review to allow someone else to replicate the search and find the same studies, including an example search strategy as specified in the PRISMA Statement.
(2) Report the date last searched, and specify which interface was used if a database is available from more than one supplier.

268

269

270